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Canadian Society of Civil Engineers.

INCORPORATED 1887.

ADVANCE PROOF—(*Subject to revision.*)

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THE INDUSTRIES OF THE CONSOLIDATED LAKE SUPERIOR COMPANY.

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During the past six years we have been hearing a great deal about New Ontario, that vast region of rock, forest and water which stretches from the Ottawa River to the Lake of the Woods. We have heard many stories of the riches of this district in minerals, pine, spruce, and farming lands, that have long been overlooked by the settler with his eye set on the golden prairies of Manitoba and the North West Territories. We have heard, too, of Sault Ste. Marie, and of the industries which are being developed there. Canadians have been watching with interest the work of the Consolidated Lake Superior Company, which has done so much to develop this comparatively unknown part of our country, and to utilize its natural resources. The object of this paper is to tell generally what this company has done, and to illustrate as far as possible how its different industries dove-tail into each other.

The enterprises of this Company are not confined to the town of Sault Ste. Marie. Its mines, railways, land grants extend from

many miles north of the "Soo" down to Sudbury, 150 miles to the east, whilst its steamers and barges carry cargoes through all the great lakes. It is those industries which are located about the Company's power canal on the Canadian side of the river which will be chiefly considered in this paper. Before describing them, it will be well, first, to take up briefly the general scheme of the Company's developments and operations under the following heads:—

(1) WATER POWER DEVELOPMENT.
(2) IRON MINES AND IRON AND STEEL OPERATIONS.
(3) NICKEL MINES.
(4) TRANSPORTATION.

1. WATER POWER DEVELOPMENT.

At Sault Ste. Marie, St. Mary's river falls through a height of 19.3 feet in a distance of about 3,000 feet. The volume of water discharged varies from 60,000 to 116,000 cubic feet per second; thus the total power represented by the water in its fall varies from a minimum of about 130,000 H.P. to a maximum of about 260,000 H.P.

The first lantern slide shows a map of the river at the rapids. There are four canals shown here. Two are ship canals, belonging respectively to the Canadian and to the United States Governments, and two are power canals belonging to the Company. The power canal on the Canadian side is of 15,000 H.P. capacity. It was finished in 1896, and has since that time been in continuous operation, supplying power for the grinding of pulp and for the driving of electric generators. This canal will be described later on.

On the American side of the river the Company's power canal has just been completed. This canal is 2¼ miles long, with a minimum flow area of 4,300 square feet. With a velocity of flow of 4½ miles per hour, the discharge will be approximately 28,000 cubic feet of water per second. The water wheels installed in the power house have an efficiency of 81% as determined by test, so that the power developed under normal conditions, allowing 0.7 feet as the loss of head due to friction in the canal and wheel pits, will be about 50,000 H.P. The power house, canal and head gates are completed, and the electrical machinery is now being installed. It is intended to use all the power for the development of electricity, which will be sold to various industrial concerns. The Union Car-

bide Company have contracted for 20,000 H.P. The cost of the canal and power house will be in the neighbourhood of $5,000,000.

In order that the water level of Lake Superior should not be lowered by the additional flow of water allowed by the opening of the company's two canals, the United States Government has provided that a dam be built, at the company's expense, in the river above the rapids. This dam will be 2,000 feet long, and will be made up of three parts. The crest of the first part will be above highwater level, the middle part will be a submerged weir, and the third section, which is already completed, consists of sluices by which the flow of water can be regulated. There are four sluices, each 48 feet wide, fitted with gates of the Stony pattern, hung on masonry. This dam is just above the C.P.R. bridge.

2. IRON MINES, IRON AND STEEL OPERATIONS.

At the present time the Company is developing two iron mines near Michipicoten. It owns also several iron propositions along the line of the Algoma Central Railway. The Helen mine, twelve miles from Michipicoten, is the one from which ore shipments have been made heretofore. In 1901 the amount of ore mined and shipped was 91,436 tons. In 1902 nearly four times this amount, or 341,750 tons, was taken by the Company's vessels to Midland, Cleveland and other points.

Ten miles north of the Helen mine is the Josephine mine. Although no ore has been shipped from here as yet, the Company has been actively engaged in developing the mine and in building a railway connecting it with the Helen mine. It is expected that next summer shipments of ore from the Josephine mine will begin.

To use the ore from its mines, the Company is erecting blast furnaces, a Bessemer plant, and a rail mill near Sault Ste. Marie. The Bessemer plant and rail mill were completed last year, and were in operation until December. As the blast furnaces were not completed, it was necessary to purchase from outside the pig iron that was used at the steel plant. Two of the blast furnaces which will supply the Bessemer plant with its pig are now nearing completion. The Bessemer plant and rail mill are splendidly equipped with the most modern types of machinery. The latter can roll some 600 tons of rails per day. An unloading dock, 2,150 feet long by 380 feet wide, is being built opposite the blast furnaces. There are to be four of these furnaces. Two will have a daily capacity

of 250 tons, and will use coke as fuel; the other two will be of 150 tons capacity, and will use charcoal. One coke furnace and one charcoal furnace are expected to be in operation by the first of May next. The coke used in the blast furnaces is brought up by boat from Cleveland. The hard wood upon the Company's land grants along the Algoma Central Railway will furnish the charcoal. Near the blast furnaces twenty by-product retorts for the manufacture of charcoal have been built. Their combined output will be about 160 cords of charcoal per day. The by-products, namely, wood alcohol and acetate of lime, are to be drawn off and saved. Besides these charcoal ovens, the company operates some fifty-six bee-hive kilns at different points along the railway.

3. NICKEL OPERATIONS.

The Company owns and operates the Elsie and the Gertrude nickel mines near Sudbury. The ore mined is a nickeliferous pyrrhotite, containing a minimum of 30% S., 50% Fe. and 3% Cu. and Ni. At the Gertrude mine a smelter has been erected and started in operation. The ores from the nickel mines containing copper are first roasted and then reduced to a 24% matte at this smelter. The ore which contains nickel without copper is taken to the reduction works at Sault Ste. Marie. Here the sulphur is driven off and used in the sulphite mill, and the roasted ore is pressed into briquettes, which are to be used in the blast furnaces to produce ferro-nickel pig. From this pig nickel steel will be made at the Bessemer plant.

4. TRANSPORTATION.

The Algoma Central and Hudson's Bay Railway is under construction from Sault Ste. Marie northward to the Josephine mine. Here it joins a branch running down past the Helen mine to Michipicoten harbour on Lake Superior. From the Josephine mine the railway will continue in a northerly direction, meeting the Canadian Pacific at Missanabi. This railway will afford a winter outlet from the Helen and Josephine mines. The country through which it passes is extremely rough. There is, however, a good deal of timber and pulp wood along the line, where the Company have been given extensive land grants by the Provincial Government. The branch from the Josephine and Helen mines to Michipicoten

harbour is in operation. This branch carries the ore from the Helen mine down to the ore dock at Michipicoten, where it is loaded into the Company's vessels. On the main line, for the first fifty-five miles from Sault Ste. Marie, the rails are laid and trains running. From the end of the rails to the Josephine junction nearly all the grading has been completed.

The Company holds a charter for the building of the Manitoulin and North Shore Railway. The branch from Sudbury to Little Current is under construction, and parties are out locating the line between Sudbury and Sault Ste. Marie.

It will be seen from the geographical position of the Company's railways that they may form an important link in the next chain of railways connecting Manitoba with the east. The McKenzie and Mann road is now in operation between Manitoba and Port Arthur. According to recent reports, it is to be shortly extended to Missanabi, and, as has been mentioned above, this will be the northern terminus of the Algoma Central Railway. Thus a second system of railways will be formed, connecting Manitoba with Sault Ste. Marie and Sudbury.

In connection with its lines of railway, the Company owns and operates a fleet of freight and passenger-carrying boats. These boats handle the outpu[illegible]m the mines, carry the timber from the saw mills to [illegible]e lower lakes, and, as return cargoes, they bring coa[illegible]plies for the numerous works of the Company. The total capacity of the freight vessels owned or chartered by the Company is about 45,000 tons.

Under the head of transportation, some mention should be made of the electric street railway which has been built on both sides of the river at Sault Ste. Marie. The road-bed and wiring has been finished, and operation now awaits only the arrival of the cars. The power will be supplied from the Company's canals. A ferry service crossing the river is to be given in connection with the street cars.

The Industries and Operations at Sault Ste. Marie, Ontario.

Having given above a general description of the operations of the Consolidated Lake Superior Company, we shall now turn our attention to the mills which have been built about the Company's power canal at Sault Ste. Marie, Ontario. Owing to the number

of these, only a short description can be given of each. The sulphite pulp mill is the only one that will be described at length. This mill has been chosen for a detailed description, as it has many novel features, and because its operation, depending as it does upon the reduction works for its sulphur dioxide gas, and upon the alkali works for its bleaching liquor, illustrates the way in which the Clergue industries help, and are helped by, each other.

Power Canal and Power House.

In the year 1894 Mr. F. H. Clergue bought from the town of Sault Ste. Marie a half finished power canal which it was struggling to complete. The work was vigorously revived, and two years later the canal and power house were completed.

This canal closely follows the course of one of the streams which once were a part of the rapids, but which were to the north of the main portion of the falls, and were divided from the rapids by St. Mary's, Whitefish and other islands. The intake to the canal is a natural bay in the river, about 2,500 feet in length, from the Canadian Ship Canal to the head gates, and varies in width from 500 to 1,500 feet. The natural bottom of this bay has been dredged to a depth at the centre of the channel of from 12 to 14 feet.

The canal proper is 2,100 feet long, 200 feet wide, and 12½ feet deep at the head gates, changing gradually to a width of 90 feet and a depth of 15½ feet at a point 50 feet from the power house, and widening again to a width of 116 feet, with a depth of 15½ feet, at the power house. The widths given are at mean water level, which is approximately 601.5 feet above mean sea level. This section of the canal is trapezoidal, the bottom being excavated in sandstone for nearly its full length, and the sides, which are on a slope of 1½ to 1 and paved with rip-rap, are formed partly by the sides of the excavation and partly by filled embankments.

The power house is an L-shaped building, the longer leg of which (known as Mill No. I) is parallel with, and the shorter leg (known as Mill No. 2) is at right angles to, the axis of the canal. The basement walls of this building form a dam, in which are openings for admitting water to the penstocks. The penstock gates slide horizontally, except in front of one penstock, and are operated by hand wheel, worm gear, rack and pinion. In Mill No. 1 there are twelve penstocks, which are built of timber, supported by masonry

piers and birch posts. The penstock floors, on which are set the turbines, are about 4 feet above tail water level, and are fitted with draft tubes. The wheel pits which carry the discharge water from the turbines to the tail race are 16 feet wide. The rock on which the power house is built is a soft red sandstone, full of cracks and seams. A good deal of trouble was experienced when the water was turned on by the undermining of the foundations. In building the mill no floor had been put in the wheel pits to protect the weak rock against the force of the water, and the floor grade was established only 4 feet below the mouths of the draught tubes. The seamy rock of the wheel pits was torn up, especially that near the draught tubes, where the velocity of the water was greatest, and carried towards the exit to the tail race. After the mill had been in operation for about three years, it was found necessary to make some repairs. A coffer dam was built along the mouths of the wheel-pits, the penstock gates were closed and the pits pumped dry. All the broken rock was cleared out and the grade of the floor lowered 2 feet. 10″ x 12″ birch timbers were bolted to the rock at intervals of 3 feet. The spaces between were then filled with concrete, and a 4 inch birch floor put on. When finished there was a smooth floor of birch at a grade of 4 feet—10 inches below the botton of the draught tubes. This construction has served well, and no trouble has since been experienced.

The tail races from the two sections of the power house are for a short distance independent, and then join in a common tail race, which is about 900 feet long, 320 feet wide and 11 to 15 feet deep, and which discharges into a natural bay in the river.

The annual mean head between the upper and lower levels of the river is 19.3 feet, and the frictional loss in the canal and tail race under the full discharge of about 8,800 cubic feet per second is about 0.7 feet, leaving a mean effective head of 18.6 feet. The total horse power developed at the turbine shafts and under mean head is 14,700, of which 8,400 is obtained in Mill No. 1 from 24-51 inch American register gate turbines of 350 H.P. each, and 6,300 in Mill No. 2 from 18-51 inch McCormick cylinder gate turbines of 350 H.P. each.

Mill No. 1 is devoted exclusively to the manufacture of ground wood pulp. There are 22 grinders, each one connected by bevel gears to a water wheel, and taking its full power. The remaining two wheels drive the wood room machinery, pumps, screens and dryers.

Mill No. 2 was first used as a pulp mill, but the grinders have been gradually replaced by generators to supply the increasing demand for electric power required to light the town and supply the numerous mills of the Company.

The Algoma Iron Works.

In the summer of 1897, when the ground wood pulp mill had been in operation some little time, it occurred to the management that a great saving in freight might be made by drying the pulp before it was shipped. The best way of doing this was found to be by the use of a 6′ x 6″ cast iron cylinder placed in front of each wet machine. This cylinder was supplied through one axle, with steam at 10 lbs. pressure, the water of condensation being carried off through a pipe entering the cylinder at the opposite axle. The sheets of pulp from the wet machine were rolled on this steam cylinder, and about 95% of the moisture was driven off.

To make some forty of these cylinders and for general repair work a machine shop 90′ x 90′ was built and equipped with a few wood working tools, a small cupola, and some machine tools. This was the commencement of the Algoma Iron Works, which to-day has an up-to-date pattern shop, foundry, blacksmith, boiler and machine shop, and which employs some 250 men.

The machine shop is a substantial two-story stone building, 160 feet long by 80 feet wide. A side track from the railway runs through the centre of the length of the building, and a 15-ton electric travelling crane runs above it, so that excellent facilities are secured for unloading and handling material. The equipment of the machine shop is very fine, the machine tools are up to date and of the best makes. They are driven by electric motors, and a steam engine is always ready, in case of emergency, to start immediately. On the main floor are situated the heavier machine tools. The second story of the machine shop is divided into two galleries 20 feet wide and running the full length of the shop. These galleries are equipped with the smaller lathes, gear cutters, turret lathes, milling machines and smaller drills. In the south gallery is located the tool room.

The boiler shop is a stone building, 90′ x 90′, adjoining the machine shop. This shop is capable of turning out some work of considerable size. For instance, they have just built two copper smelting furnaces for the Lake Superior Power Company. These

furnaces are of ⅝ inch plate, 5'-4" x 10'-6" x 9' high. The roasters for the reduction works were also built in this shop, and three Spiegel cupolas, 66" in diameter by 23' high for the steel plant.

The blacksmith shop adjoins the machine shop on the west side, and is 88' by 96'. It is equipped with a good set of furnaces, forges and hammers.

The foundry is at a distance of some 100 yards from the machine shop, and is connected with it by rail. It also is a stone building, 62' wide by 190' long. The main floor is covered by a fifteen-ton Nile's electric travelling crane. There is also one five-ton jib crane, and four one-ton jib cranes operated by air. They have a ten-ton melting cupola and also one of five tons capacity. One end of the building is devoted to cupola, core ovens, and furnaces of the brass foundry.

Next to the foundry is the pattern shop, a steel building covered with corrugated iron, 50' x 70', where, besides making the patterns for the foundry, a good deal of general carpenter work, such as making window frames and doors, is done.

These shops of the Algoma Iron Works have furnished the entire equipment of the sulphite mill, with the exception of the digesters and motors. In the ground wood mill they have built all the machinery except the water wheels and the wet machines. They have recently built, from their own design, a 40" turbine for the Lake Superior Power Company, which will be used in the future. It is evident that they are pretty well equipped for making pulp and paper machinery. In metallurgical work they have had some experience also, having erected the whole equipment of roasters for the reduction works, a Bessemer cupola of 8 tons per hour capacity, two copper smelters with a daily capacity of 200 tons each. For the Algoma Central Railway they furnish, from their own designs, all track works, including switches, frogs and crossings.

The Reduction Works.

The function of this plant is two-fold. First, it has to produce a combination of nickel and iron suitable to be used in the blast furnace for the production of ferro-nickel pig, and, second, it must supply sulphur dioxide gas to the sulphite mill for making the acid there used, and to the sulphurous anhydride plant, where liquid sulphurous anhydride is manufactured. The raw material supplied to the reduction works is nickeliferous pyrrhotite from the Com-

pany's mine at Sudbury. As was stated above, this pyrrhotite contains a minimum of 30% S., 50% Fe. and 3% Cu. and Ni. Of this ore only that which contains a low percentage of copper is treated at the reduction works, the remainder is smelted at Sudbury.

The reduction works are made up of a crushing plant, a set of sixteen roasters, and a briquetting plant. The pyrrhotite ore is first broken up into fine particles, which will pass through a screen of 1-16" mesh. It is then taken by conveyors to the roasters.

In principle, these kilns are of the McDougal type, arranged to suit the character of the pyrrhotite. They are fitted with burners for using water gas. Their combined capacity is about 50 tons per day. The object of the roasting is to desulphurize the pyrrhotite. On entering the roasters the powdered ore is first subjected to an indirect or muffled heat, sufficient to dry it and cause it to be ignited. It is continually stirred to prevent its caking or clinkering, and is simultaneously moved forward towards the furnace outlet. In the last stage of its passage it is subjected to a more intense heat. Between the initial and final application of heat, that generated by the oxidation of the combustible matter added to that radiated from the furnace is generally found sufficient to maintain the process of oxidation between the two stages. In the course of the ore through the furnace the sulphur is oxidised and drawn off as sulphur dioxide gas by a suitable flue. This gas passes through a dust separator and through cleaning towers, and is then drawn off for use in the sulphite mill or the sulphurous anhydride plant.

The "cinders" resulting from the roasting of the pyrrhotite are oxide of iron, containing about 3% nickel and about 0.75% sulphur. This product is pressed into briquettes suitable to be used in the blast furnace in the manufacture of ferro-nickel pig. This pig can afterwards be made into ferro-nickel steel, either by the Bessemer or by the open hearth process.

Sulphite Mill.

Canada, as a pulp producing country, is becoming daily more important. It will continue to do so more in the future than in the past, as the forests of Sweden and the United States become depleted. Our neighbours to the south of us have in many instances exhausted their supply of raw material, and are looking to us to supply the deficiency. Along the Canadian shores of the great lakes camps have been established for the purpose of cutting and

shipping spruce to the American mills. The great paper mills at Niagara Falls, for instance, cut their supply of spruce on the north shores of Lake Superior and Lake Huron. Canadians are beginning to appreciate the advantages which this country offers for the manufacture of pulp, and, as a result, many mills have been built during the past few years. At Chatham, N.B., Grand Mere, Shawinigan, Sturgeon Falls, Sault Ste. Marie, and at many other points the industry has been established.

At Sault Ste. Marie the ground wood mill, mentioned above, has a daily capacity of about 100 tons. A sulphite mill, designed for a daily output of 60 tons, was finished a years ago. A paper mill to use their products is a natural sequence, and, on a recent visit to the "Soo," the writer was informed that plans had been prepared for one to be built on the American side of the river. The pulp from the Canadian mills can be taken across to the paper mill in tank barges at very small expense. The "Soo" as a centre for pulp industry possesses many advantages, the chief of which are—That the necessary raw material is found in the neighbourhood, and that power can be developed at a very low cost. The country from the great lakes to Hudson's Bay contains vast areas of spruce forests, from which the wood is cut. The rapids of St. Mary's river furnish the power.

In the manufacture of paper, a mixture of ground pulp and chemical pulp is used. The ground pulp forms the body of the paper, and the chemical pulp gives it the necessary fiber.

The percentage of the two kinds of pulp used varies with the kind of paper to be made. For rough newspaper 15 to 25% sulphite is used, while for Manilla paper from 50 to 100% is used. As sulphite costs about twice as much as ground wood pulp, the object of the manufacturer is to keep the percentage of the former as low as possible. Ground wood pulp is made simply by grinding barked spruce logs with great circular stones, on which they are pressed by hydraulic jacks. After a small amount of screening, the pulp is ready for the wet machines. In the manufacture of sulphite pulp the cost of the chemicals used is considerable. The sulphite pulp itself is made by cooking spruce chips in calcium sulphite liquor $Ca. SO_3 + H_2O$. This liquor is made usually by burning sulphur and passing the gas formed through lime water. The sulphur used in most American mills is imported from Sicily at a cost of 25 to 30 dollars per ton.

In the sulphite mill at Sault Ste. Marie the sulphur dioxide (SO_2) gas used in the manufacture of the calcium sulphite liquor, is

obtained as a by-product from the pyrrhotite reduction works, and thus a considerable saving is effected. At most roasting plants this gas is allowed to pass away into the atmosphere. At one point, where the train passes near Sudbury, the vegetation of a whole hillside is burnt and withered as a result of the sulphur fumes from a smelter. The same thing can be seen at Trail, B.C. At the "Soo," as has been mentioned above, this gas is drawn off from the roasters, and is passed through a dust separator and cleaning towers, where it is purified and washed. When the gas, which contains 5% to 9% sulphur dioxide mixed with air, has been thoroughly cleaned, it is blown over through a lead pipe to the acid plant at the sulphite mill.

In this plant are eight wooden towers, each 5 feet inside diameter, 95 feet high. They are filled with broken limestone, supported at several points by wooden grates. At the top of each tower is a water pipe and sprayer, arranged to distribute the water over the limestone; at the bottom is a gas connection leading to the pipe from the reduction works. To make the calcium sulphite liquor, the gas is turned on at the bottom of a tower, and is forced up through the broken limestone; at the same time water is turned on at the top of the tower, and flows down through the limestone. Two reactions take place—first, the sulphur dioxide combines with the water to form sulphurous acid

$$S\,O_2 + H_2\,O = H_2\,S\,O_3$$

This acid then reacts upon the carbonate, which is present in the form of limestone. The reaction is represented by the equation

$$H_2\,S\,O_3 + Ca.\,C\,O_3 = Ca.\,S\,O_3 + H_2\,O + C\,O_2$$

The strength strength of the sulphite liquid or acid flowing out at the bottom of the tower depends on the percentage of the sulphur dioxide in the gas and on the quantity of gas used. In order that the proper action may take place in the digesters, the percentage of sulphur dioxide in the liquor must be at least 4%. If the gas from the reduction works contains less than 8% of sulphur dioxide, the acid drawn off from the bottom of a tower is found to be under the required strength. In this event it is pumped up to the top of a second tower similar to the first, where it takes the place of the water supply. Its strength is here increased until it contains the necessary percentage of sulphur dioxide, i.e., 4%. It is then pumped to storage tanks, where it is kept until needed. There are four of these tanks, holding 30,000 gallons each.

In the preparation of the wood, the spruce logs are first sawn into two-foot lengths, and these pieces are taken by means of a water conveyor to the barkers. There are 8 of these machines, with 5-foot cast iron disks. Each disk has 3 knives attached to it it, by which the logs are barked. The logs are then carried by a chain conveyor to the chipping machine, where they are cut into chips ¾ of an inch long. These chips are crushed and screened, and are ready to be taken over to the sulphite mill. So far the wood has been treated in what might be called a chip-preparing plant or wood room. This is situated at a distance of 260 feet from the mill. The chips are transferred from one building to the other by means of a 16″ spiral screw conveyor. On reaching the mill they are carried by an elevator to the top of the building, and dumped into a bin holding 28,000 cubic feet. This bin is fitted with sliding gates above the digester mouths. By opening one of these gates a digester can be filled in about twenty minutes.

The actual chemical treatment by which the wood is turned into pulp is as follows:—6,460 cubic feet of chips are first put into a digester, filling it to within 10 feet of the top; then 30,000 gallons of 4% acid is pumped in, filling the digester to within about 13 feet of the top. The cover is screwed down and dry steam, at 80 lbs. pressure, is admitted at the bottom of the digester through a 5″ pipe. The pressure in the digester (and consequently the temperature) is gradually raised, until at the end of four or five hours it has risen to 75 lbs. per square inch. At the end of this time, to prevent the digester being filled with water of condensation, a valve on the top of the digester is opened and a mixture of sulphur dioxide, with partially condensed steam, is taken off and passed through a separator, which passes the condensed water to the sewer. The gas is drawn off, cooled, and then returned to the storage tanks, where it is used to strengthen the liquor. Steam is kept on the digester until the pressure rises to 90 lbs. and the temperature to 300° F. This temperature is maintained until the pulp is thoroughly cooked, the time required being from 10 to 12 hours. Towards the end of this time tests are made at short intervals to ascertain the exact condition of the pulp. When it is cooked so that the liquor in the digester contains not more than ¼% of sulphur dioxide, the steam is shut off, and the pulp is blown out of the bottom of the digester through a 12-inch pipe into the blow pits. About 17 tons of pulp are made in each cook, so that in the two digesters about 60 tons can be produced daily.

In the blow pits the pulp is thoroughly washed and all liquor drained off. From these pits it is pumped up to an agitator, broken up and diluted with water. The pulp then follows through a set of six coarse screens, which take out all the larger chips, over a riffler where all sand, ets., are settled out, and through a set of sixteen fine screens, which remove all remaining impurities. The pulp then passes to storage tanks, from which it is pumped, as required, into the wet machines, which roll it out and carry it to the dryers, where the percentage of moisture is reduced to from 15 to 20%. The pulp, 80 to 85% dry, is then ready for shipment in the form of a sheet rolled up.

The mill where the above process is employed consists of three buildings—the sulphite mill proper, the chip-preparing plant, and the boiler house. The chip-preparing plant is a building 200 feet long by 50 feet wide, situated at a distance of 260 feet from the sulphite mill. Here 150 cords of wood can be prepared daily. One saw, 8 barkers, 1 chipper, 1 crusher and screen are so connected by conveyors that this amount of wood can be passed in in the form of 16-foot logs, and come out in the form of ¾″ chips. A 200 H.P. motor furnishes the power required.

The saw-dust, bark and screenings are carried by a float conveyor to the boiler house, and are there burnt on special grates, furnishing some 300 H.P. To eliminate the danger of sparks from the chimney, an ingenious device is used. A fan draws off the gases of combustion, and passes them through a vertical pipe, whose bottom end dips 2 inches into a tank of water. Thus a water seal is formed which catches and extinguishes all sparks. The tank is connected to the stack, and the smoke passes off in the usual manner. In the boiler house are five Stirling water tube boilers, each of 250 H.P. capacity, and a Green's economiser, which is used for heating the feed water.

The acid plant, which forms a wing of the sulphite mill, has already been described, so we shall now pass on to the sulphite mill proper. This is a red sandstone building 170 feet long by 70 feet wide by 120 feet high in front. The front portion is occupied by two digesters. These are great vessels, 17 feet diameter by 54 feet high, made of steel boiler plate 1¼ inch thick. The cubical contents of each digester is 7,000 cubic feet; the weight when filled is 450 tons. To carry this enormous load the foundations were carefully made, and were taken down to the solid rock. Each digester is carried by eight cast iron columns, 12″ diameter, 2″ thick,

set on a circular masonry foundation. The steel work of the building does not help in any way to support the digesters; they are carried entirely from below. To protect the steel shell of the digesters from corrosion by the acid, a special lining is used. It consists of three layers of brick, each layer being 2″ thick. Several kinds of brick were tried for this purpose. The one which gave the best satisfaction was a brick made of crushed granite. One digester was lined throughout with these brick, and it has been in operation now for over a year without any repairs. In the lining of the other digester two kinds of brick were used—one a hard, vitrified brick, and the other a variety of fire-brick. After these had been in use a short time, it was found necessary to replace them by those made of crushed granite. The cement used in lining the digesters was made by mixing one part of Portland cement with two parts of finely crushed granite; a solution of silicate of soda was used instead of water. The cement set very quickly, five minutes giving an almost perfect set. It was mixed in very small amounts and applied instantly. The bond between the bricks and the shell and between the bricks themselves was excellent. It was found in many tests that the bricks themselves would break rather than separate from the cement. Since that time this cement has been used by the writer in several cases where quick setting and great strength and hardness were necessary. For instance, in repairing leaks in the bottoms of gas holders, where there was a pressure of water from without, the flow was stopped by using bricks set in this cement. It costs about 50% more than cement prepared in the ordinary way.

Behind each digester, and connected to it by a 12″ pipe, is a blow pipe 45 feet by 28 feet by 16 feet deep. The walls of each pit are of masonry 4 feet thick, lined with timber to withstand the great force of the pulp as it is blown from the digesters under 80 lbs. steam pressure. The bottom is lined with 2″ planks, set on a solid foundation of concrete. These planks have perforations 3-16″ in diameter in them, through which the liquor that is left in the pulp is drained off. From the top of each blow pit a timber pipe 10 feet by 12 feet carries off the gases to the atmosphere.

In the screening rooms are 6 coarse screens and 16 fine screens. These 16 fine screens have been found capable of passing only 25 to 30 tons a day. Two centrifugal screens of a capacity of 15 tons each are now being added. There are 4 wet machines, each connected to a drying machine. These are made at the "Soo" by the

Algoma Iron Works. In fact, most of the machinery in this mill, with the exception of the digesters and motors, was made by the Company.

There are 4 wet machines, having a capacity of 15 tons each per 24 hours. Each wet machine is made up of a tank 6′ long, in which revolves a hollow cylinder covered with fine wire gauze. An endless blanket passes over this cylinder and over a set of wooden rollers. The tank is kept filled with pulp of about the same consistency as cream. Most of the water with which the pulp is mixed forces its way through the blanket and through the gauze cylinder, and is drained off, leaving the pulp adhering to the blanket in a thin layer. The blanket carries it between a pair of wooden rolls, where about 50% of the moisture is squeezed out and the pulp layer made strong enough to carry itself. It is then separated from the blanket and passed to the drying machine, where it is dried by passing in succession over three cast iron steam-heated cylinders. The dry pulp is taken off in rolls of 250 lbs. ready for shipment.

At the present time the mill is turning out from 20 to 25 tons of finished product. This output will doubtless be largely increased in the near future. The screens have not been able to properly handle more than this amount, and some trouble has been experienced in manufacturing the acid from the by-product gas given off at the pyrrhotite reduction works. In the ordinary process of making sulphur dioxide by burning sulphur, it is comparatively easy to get a gas running 10 percent sulphur dioxide. In the reduction works at the "Soo" it is very difficult to approach this figure, as the pyrrhotite must be dead roasted. In order that it can be used in making nickel steel, the product of the roasters must contain less than 1% of sulphur. To bring the percentage as low as this a heavy air blast must be used in the roasters, and hence the gases given off contain a large percentage of air. So far, they have succeeded in producing gas running about 5 to 6% sulphur dioxide. By changing the arrangement of the acid towers, i.e., putting two towers in series and increasing the velocity of the flow of gas through the towers, it has been found possible to make an acid of the necessary strength, i.e., one containing 4% sulphur dioxide. The screening capacity of the mill is being increased by installing two centrifugal screens of a daily capacity of 15 tons each. There is every reason to hope that the mill will soon be turning out about 50 tons of sulphite pulp daily. At present the mill is turning out unbleached pulp. Arrangements have been made with the

Canadian Electro-Chemical Company to supply the bleach liquor, and bleach tanks have been erected in the basement of the sulphite mill.

Before finishing w. h the sulphite pulp industry as it exists at Sault Ste. Marie, it will be interesting to examine some figures on the cost of production. To make one ton of pulp the raw material required is 2.2 cords of wood, 500 lbs. of sulphur dioxide gas, and 450 lbs. of lime stone. Delivered at the mill, these materials cost as follows:—Wood, $5.00 per cord; gas, $15.00 per ton; limestone, $1.75 per ton—that is, the raw material used in making one ton of pulp costs about $15.00. The cost of coal, labour and power is about $10.00 per ton of pulp produced, so that the total cost per ton is very nearly $25.00. As the present market price is $30.00 per ton, f.o.b. cars, Sault Ste. Marie, the profit per ton is in the neighbourhood of $5.00. If the ultimate capacity of the mill be 50 tons per day, or 15,000 tons per year, the annual income would be about $75,000.00, which, after paying for repairs, insurance, depreciation, etc., should leave enough to pay a fair dividend on the capital invested. It is only fair to remember that the existence of the sulphite mill adds largely to the profits from the reduction works. If it were not for the sulphite mill, the gas from the roasters would be thrown away. As 12½ tons of gas (at $15.00 per ton) are required to produce 50 tons of sulphite pulp per day, we can see that the sulphite mill should add in the neighbourhood of $185.00 per day to the profits of the reduction works.

Alkali Works.

Messrs. The Canadian Electro-Chemical Company, Limited, of Sault Ste. Marie, Ontario, are manufacturers of caustic soda and bleaching powder, and their process of manufacture is covered by Canadian Patents, Nos. 61369, dated 12th October, 1898, and 75682, dated 29th April, 1902.

The process in question is an electrolytical one, with the aid of a mercury cathode.

As is well known, all electrolytical processes for the manufacture of caustic soda and bleaching powder depend upon the fact that if a saturated solution of salt be subjected to the passage of an electric current, by having two poles placed in the solution, th salt will be decomposed, chlorine being given off at the positi e pole, and sodium being thrown down at the negative pole. Simple as this

process may appear, it is beset with many difficulties, and many plans have been devised to obviate them.

Some of the great difficulties that stand in the way of producing an economical and practicable process are—1st, isolating the products of electrolysis, so as to prevent chemical reactions, which cause the loss of electrical energy and a contamination of the electrolyte; and 2nd, the question of producing large quantities of chemicals by a plant that would not be too excessively large, and the cost of which would be reasonable, and which would cost little for maintenance and repairs.

To overcome these difficulties various methods have been suggested and tried. Generally, the methods employed may be divided into two classes, viz.—1st, those in which some form of porous diaphragm is used with the object of mechanically separating the electrolyte from the alkaline solution, whilst allowing the current to pass; 2nd, those employing mercury as a cathode.

When a film or layer of mercury is made the negative pole, the sodium which is thrown down upon the surface of it immediately forms an amalgam with the mercury. The essence of the mercury kathode process is, that this amalgam be immediately removed from the chamber through which the current passes into another chamber containing water, which extracts the sodium and forms sodium hydrate, giving off hydrogen.

The chlorine given off at the positive pole is conveyed into chambers containing slaked lime, the resulting product being known as bleaching powder.

The greatest problem in all electrolytical work is to make the apparatus lasting. In order to effect this, the surface exposed to the different chemicals must be of such a nature as to be attacked as little as possible. Hence it is of vital importance that no metallic substance should be exposed to the action of chlorine.

The cell employed by the Canadian Electro-Chemical Company is a very simple one. It consists of an outside shallow dish or containing vessel made of cast iron. Inside this iron vessel there is another vessel made of earthenware, from the bottom of which a series of open necks project, the edges of which pass down beneath a layer of mercury, which is placed in the bottom of the iron vessel. In the centre of the top of the earthenware vessel there is a cylindrical opening or tube, which has a water seal at the top. This cylindrical pipe is made to revolve on its centre axis, so that the whole of the inside vessel is carried around the centre axis of

this pipe, which is kept in place by a bridge which spans the upper portion of the iron containing vessel. The revolution of the earthenware vessel, i.e., the electrolytic cell proper, is accomplished by a worm gear.

The top surface of the electrolytic cell has six or more upward protruding necks, each of which is perforated by a number of holes, through which carbon rods are inserted. Around the top centre pipe of the electrolytic cell there is a ring of metal, which is carried around when the vessel revolves. All the carbon rods are connected up to this ring by suitable metallic leads. A sliding contact on the metallic ring around the centre top pipe of the electrolytic cell connects the carbons with the positive pole of a dynamo or other source of electricity. The negative pole of the dynamo is connected to the cast iron containing vessel. The action of the cell is exceedingly simple. The layer of mercury forms a seal with the downward projecting edges of the electrolytic cell, so that when the cell is filled with brine, and the outer annular space is filled with pure water, no connection between the liquid contents of these two compartments can possibly take place.

When the electric current passes through the cell, it passes from the lower ends of the carbon rods through the brine to the mercury surface.

The chlorine is given off at the surface of the brine, and is carried away through the top centre pipe to the bleach chambers.

The sodium mercury amalgam forms upon the surface of the mercury inside the downward protruding necks at the bottom surface of the brine, and passes, partly by diffusion and partly by mechanical agitation of the mercury occasioned by the revolution of the electrolytic cell, to the outer annular space, where a layer of water extracts the sodium in the form of caustic soda.

The mechanical agitation of the mercury is assisted by placing radiating vanes in the bottom of the cast iron containing vessel, which conduct the mercury to the outer edge of the vessel.

In order to permit the very highest current density, the electrolytic cell should always contain a concentrated solution of salt, which also reduces the electrical resistance of the cell, and permits the use of the very lowest potential difference. This existence of concentrated brine in the electrolytic cell is effected by a constant circulation of the liquid.

When the caustic soda solution reaches a strength of 23 degrees

Beaume (200 grams per litre), the solution is drawn off and conveyed into a sheet iron store tank. The exact amount of such solution produced per hour by the current used is drawn off continuously, the outer annular space consequently always contains a 23 degree Beaume solution of sodium hydrate.

The chlorine given off at the positive pole, as already stated, is drawn off through a pipe in the centre of the top of the electrolytic cell, and, through a system of earthenware piping, conveyed into the bleach chambers by means of suction. These chambers are connected up so as to permit any one of them being disconnected from the main chlorine supply pipe. When the slaked lime spread out on the floors of the chambers has absorbed chlorine gas to the extent of 36-38% of its own weight, the bleaching powder is ready, and is packed into barrels through discharge pipes.

At the Canadian Electro-Chemical Company's works at Sault Ste. Marie, Ontario, electrical current is being developed by water power. The electrical installation consists of three 220 K.W. dynamos, each developing 1,000 amperes at a potential difference of 220 volts. These dynamos are of the most modern design, and furnished by the Canadian General Electric Company, of Peterborough. Each dynamo is driven by a separate water wheel.

The electrolytical installation comprises 120 cells, divided into three units of 40 cells each, each unit deriving its electrical power from one of the above dynamos, the cells being arranged in series. A current of 1,000 amperes, at a potential difference of 5 volts, is passed through each cell.

The cellroom also contains two brine tanks of 2,000 cubic feet capacity each, from which the brine flows by gravity to the electrolytic cell. The brine is pumped continuously from the cells back into the brine tanks, where it is strengthened and made ready for re-use in the cells.

Ten 5-ton bleach chambers, made entirely of sheet lead, and provided with a 2" tile floor, are used for the manufacture of the bleaching powder.

Disentegrator and dressing machinery for the daily output of 14 tons slaked line are provided.

The evaporation plant consists of 1,000 cubic feet sheet iron store tank, weak liquor apparatus and finishing kettles.

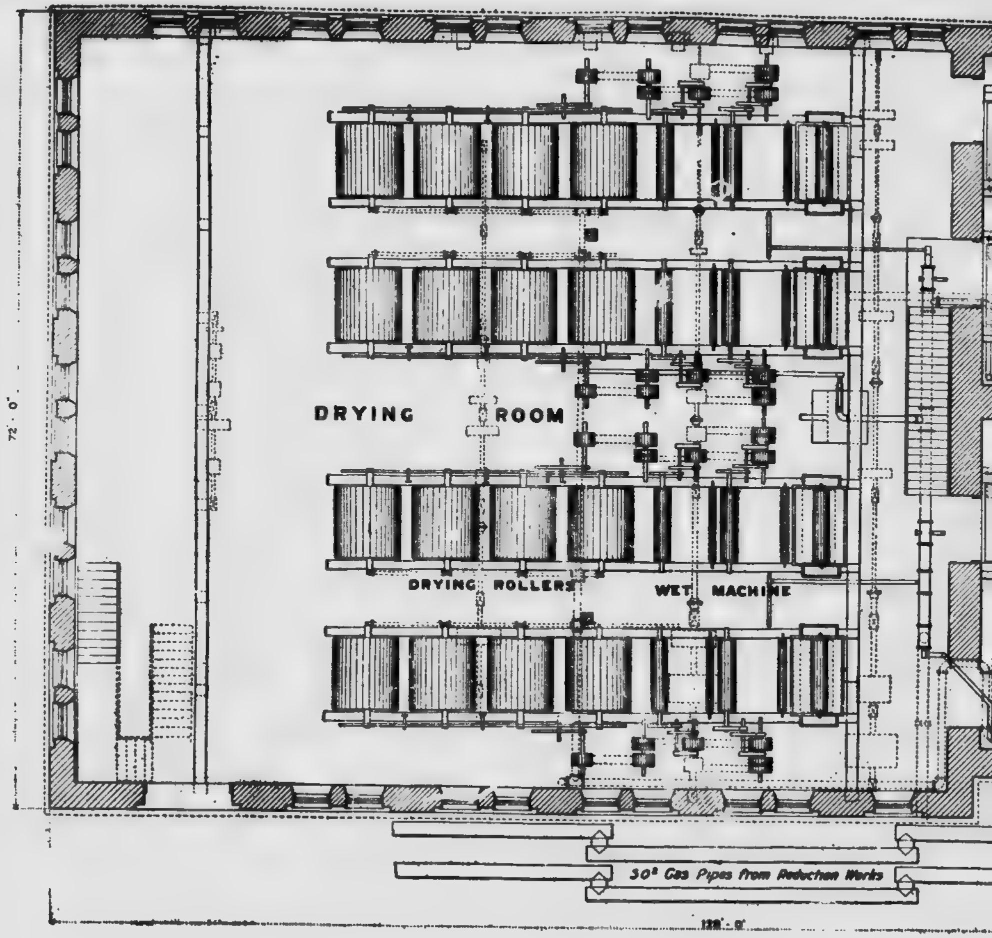
The daily output of the factory at full capacity would be, each

cell using 1,000 amperes at a potential difference of 5 volts, with an A.H. efficiency of 90%:—

9 tons 941 lbs. of bleaching powder.
4 tons 565 lbs. of caustic soda.

Whilst it is impossible in a paper of this kind to give any detailed account of the various engineering developments of the Consolidated Lake Superior Company, perhaps enough has been said to enable the reader to form some idea of its operations. To become better acquainted with its various works he should make a personal visit. There has been some talk amongst the members of the Canadian Society of Civil Engineers of having Sault Ste. Marie as the objective point of our annual excursion in the coming summer. No place in Canada could be more likely to interest the members of every branch of engineering. Nowhere but at Sault Ste. Marie could so many interesting engineering developments be seen in so small a compass. There within a mile's radius civil engineers will find power developments, ship canals fitted with locks which are amongst the largest and finest of the world, compensating works and splendid industrial buildings. The mechanical engineer will be interested in the equipments of the various industries. Those engineers who are interested in chemistry and mining will have chemical and electro-chemical works to visit, iron and nickel mines and processes of reduction to study. The electrical engineer will perhaps be able to gain some information from seeing the development of some fifty or sixty thousand electrical horse-power, and following its utilization for all sorts of purposes.

It is upon the success of such enterprises as the Consolidated Lake Superior Company and the Dominion Iron and Steel Company that the development of Canada as a manufacturing country so largely depends. In a country such as ours—poor in capital but rich in its natural resources—it must ever be our aim to investigate and develop these resources, and to that end not only invest our own capital, but interest that of more wealthy countries. In both the cases mentioned above a large part of the necessary capital and energy has come from abroad, but this country has the greatest interest in the work that is being done.



THE SAULT STE MARIE PULP AND PAPER

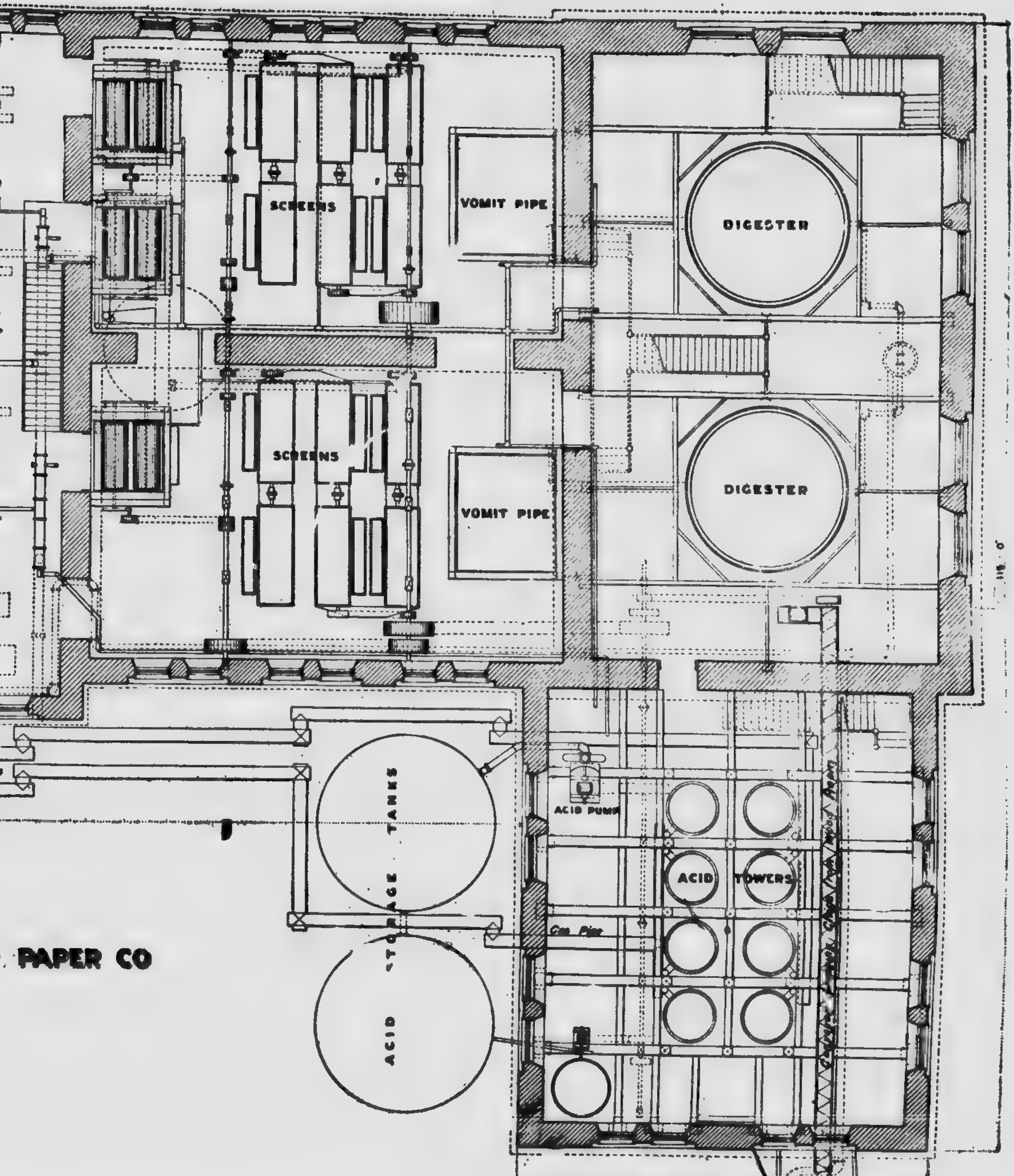
SULPHITE PULP MILL

SAULT STE MARIE. ONT.

SECOND FLOOR PLAN

cale of Feet.

TRANSACTIONS CAN. SOC. C. E.
VOL. XVII PLATE 8



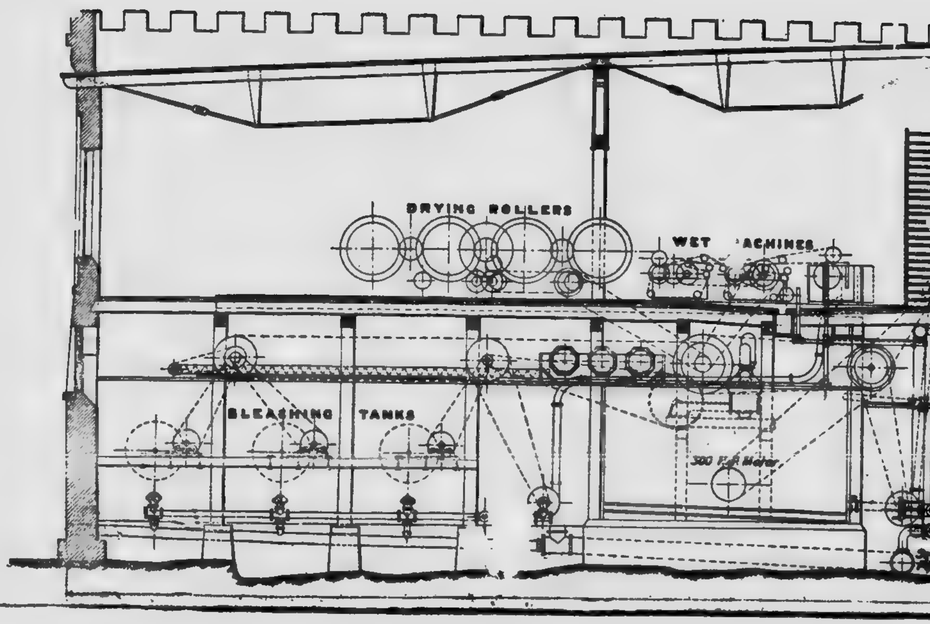
THE SAULT STE MARIE PULP AND PAPER C

SULPHITE PULP MILL.

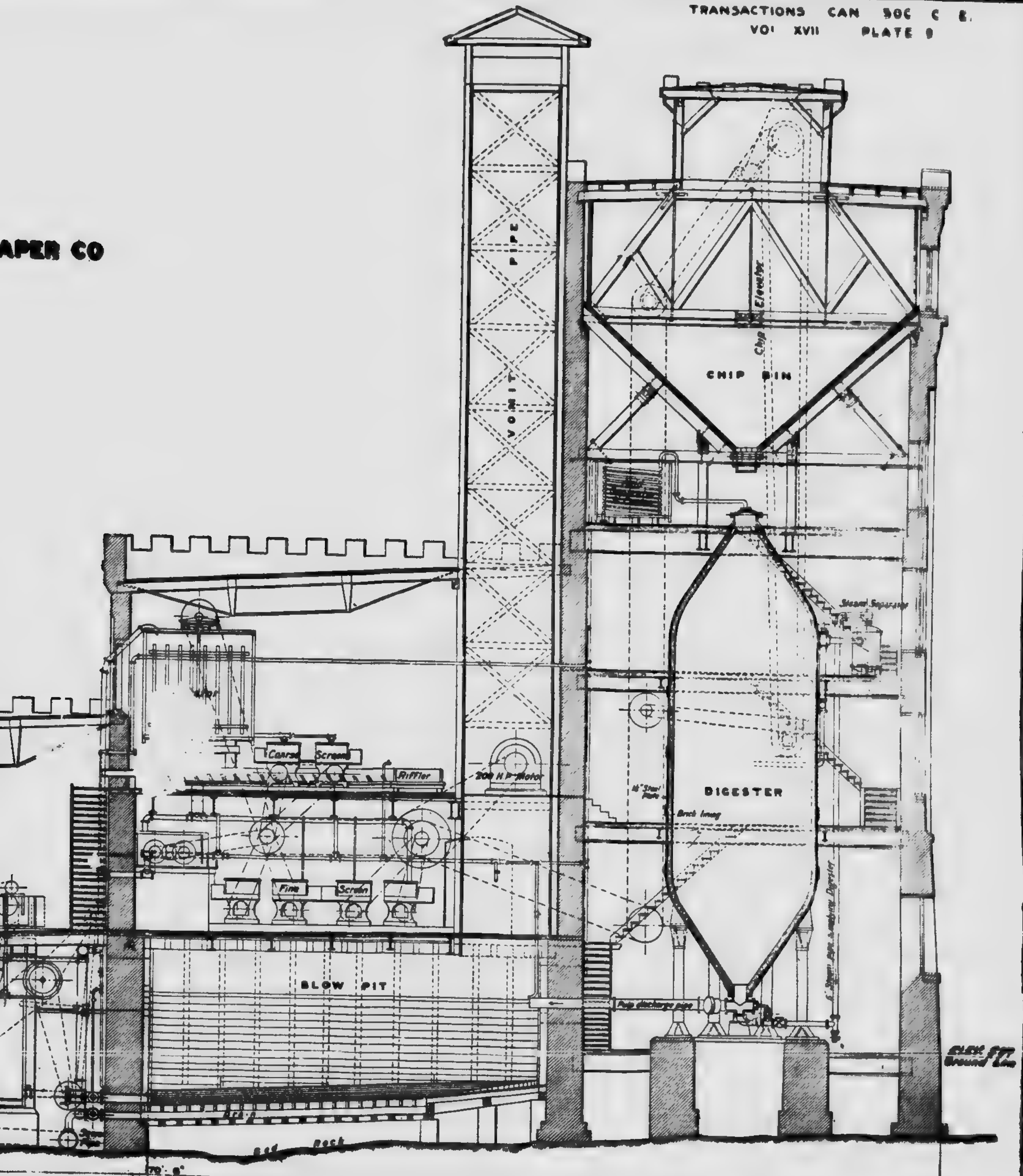
SAULT STE. MARIE, ONT.

LONGITUDINAL SECTION

Scale of Feet.



TRANSACTIONS CAN SOC C E.
VOl XVII PLATE 9



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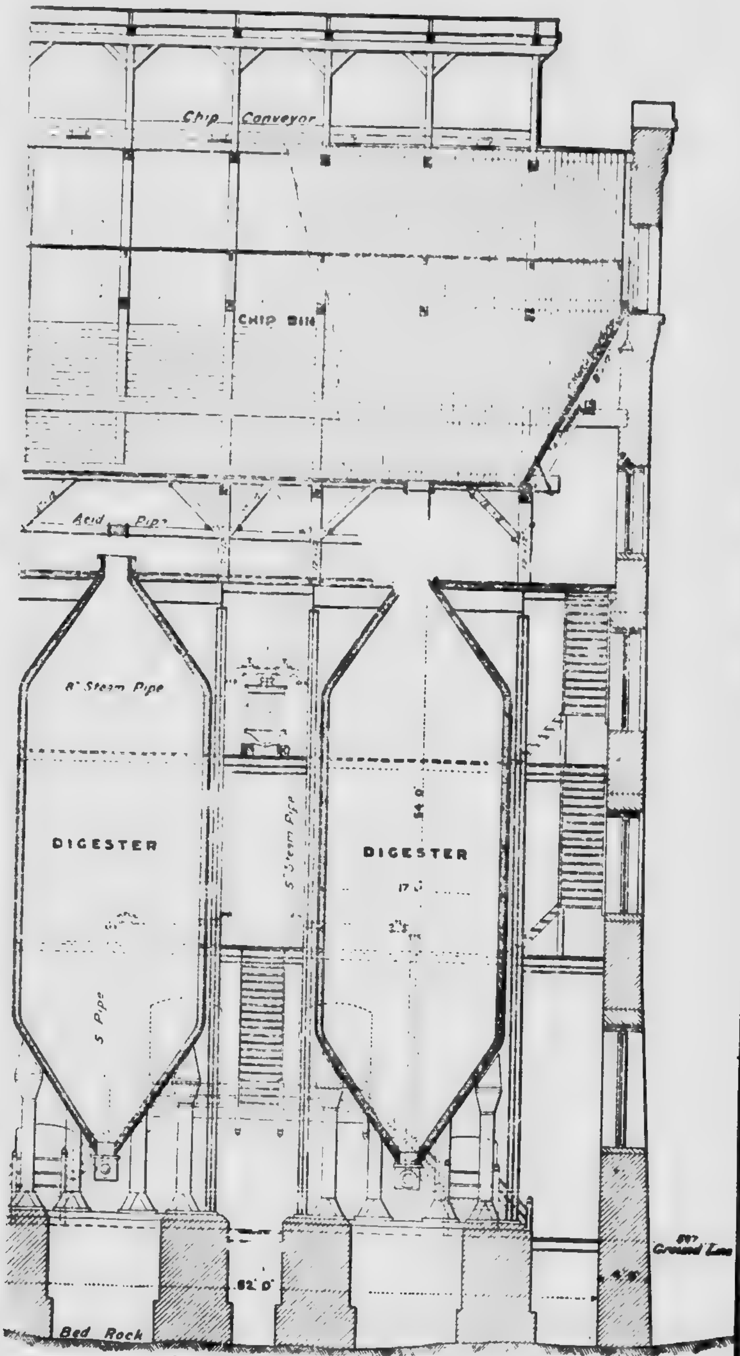
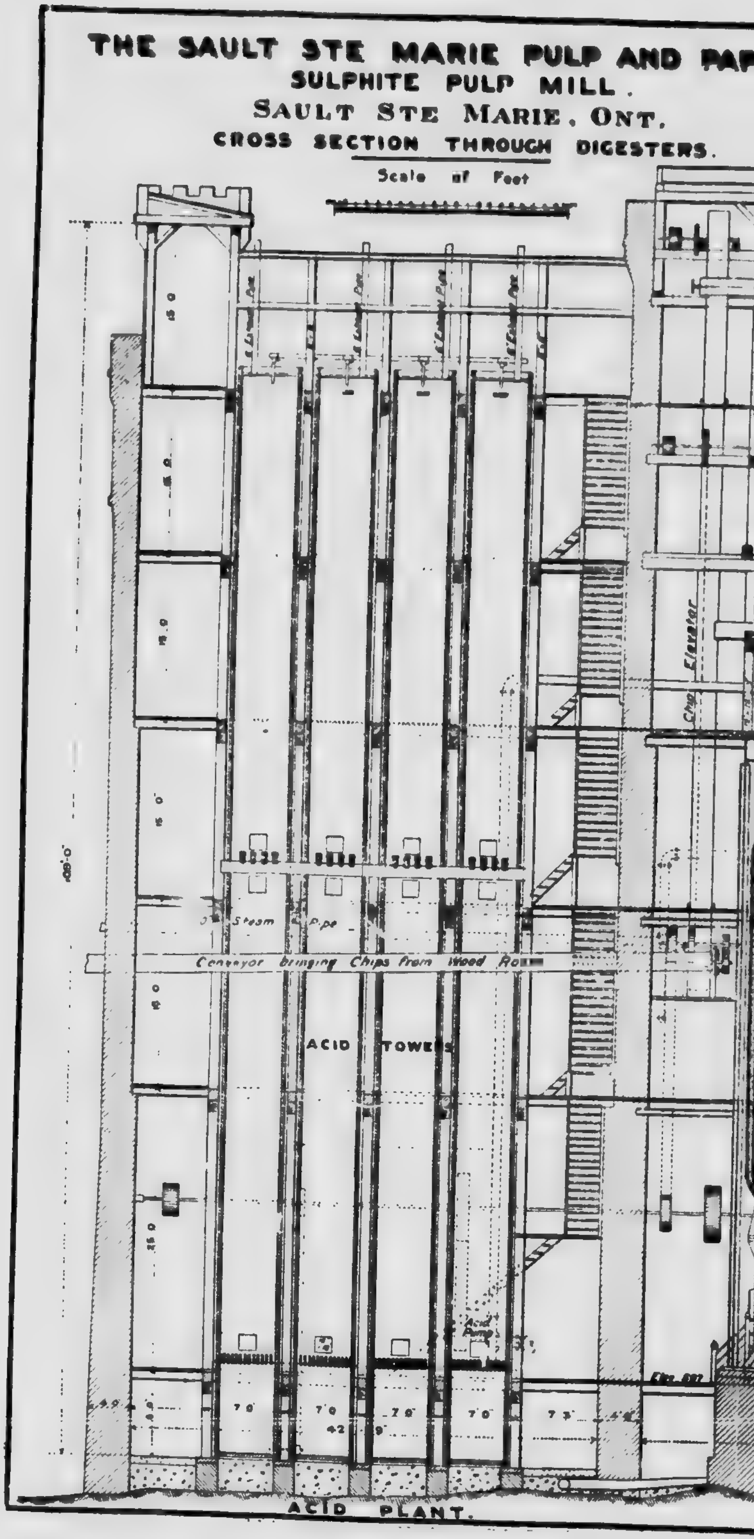
TRANSECTIONS CAN. SOC C. E.
VOL. XVII PLATE 10



DIGESTER HOUSE.

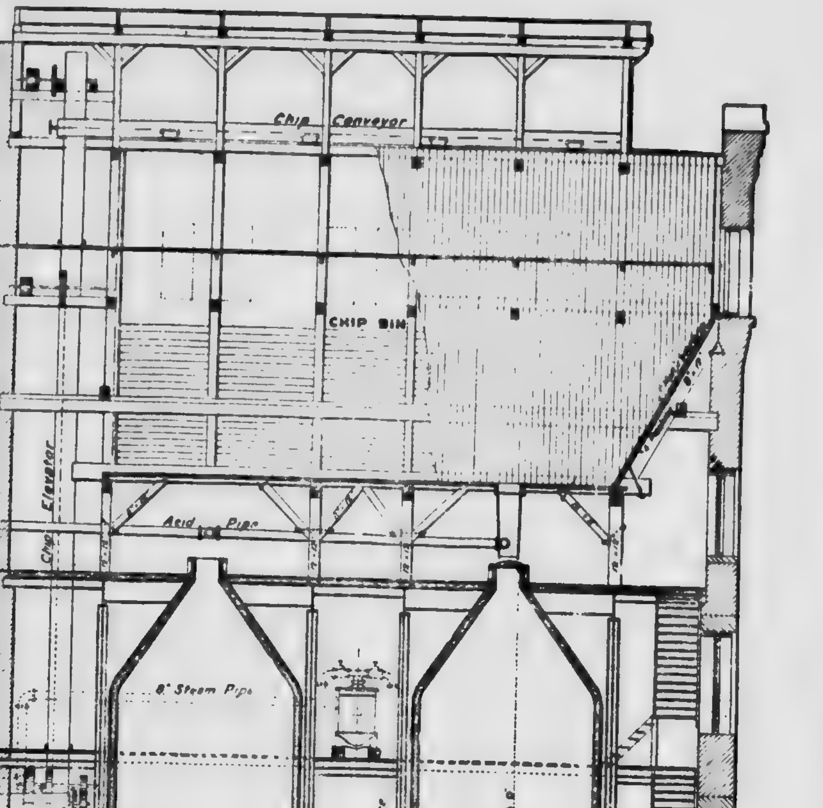

THE SAULT STE MARIE PULP AND PAP
SULPHITE PULP MILL.
SAULT STE MARIE, ONT.
CROSS SECTION THROUGH DIGESTERS.
Scale of Feet
Steam Pipe
Conveyor bringing Chips from Wood Room
ACID TOWERS
Chip Elevator
ACID PLANT.

ND PAPER CO.

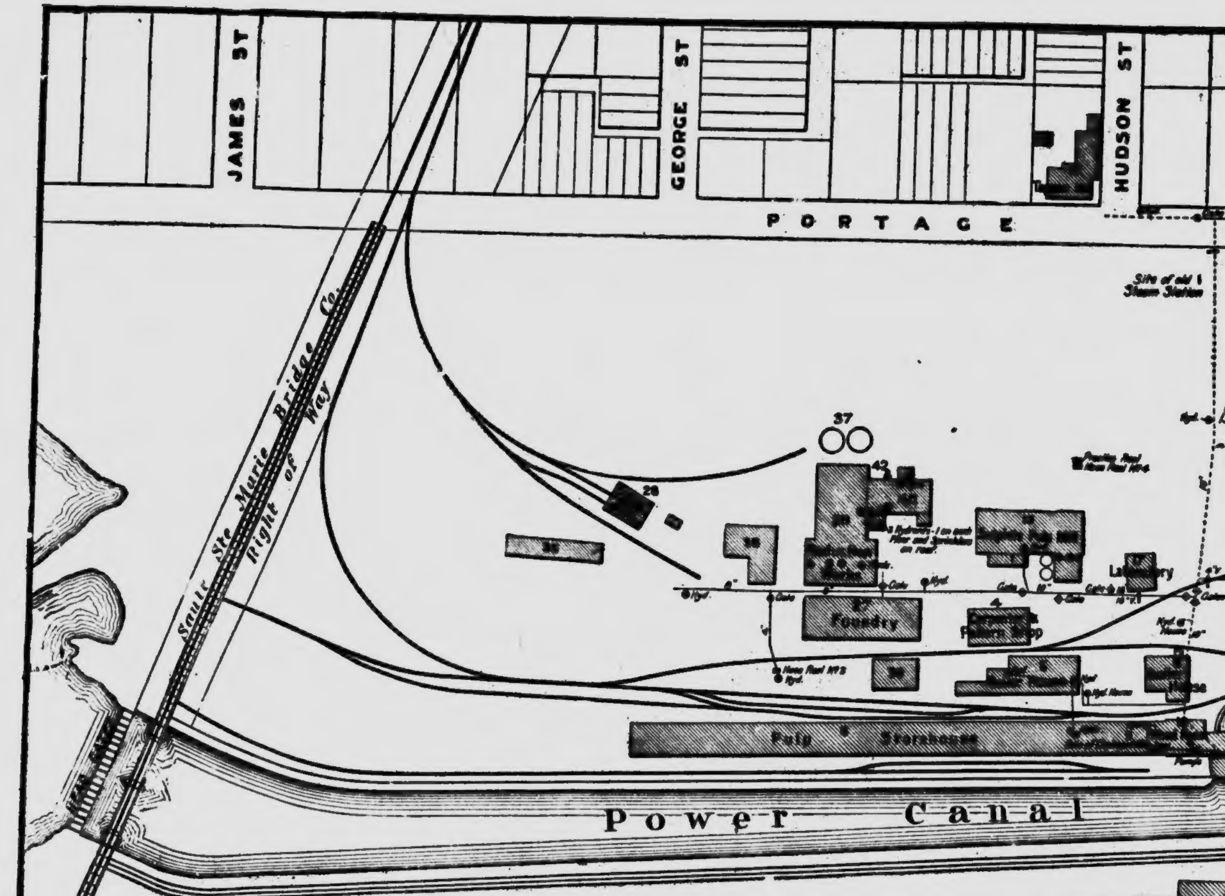
TRANSACTIONS CAN. SOC. C. E.
VOL. XVII PLATE 10

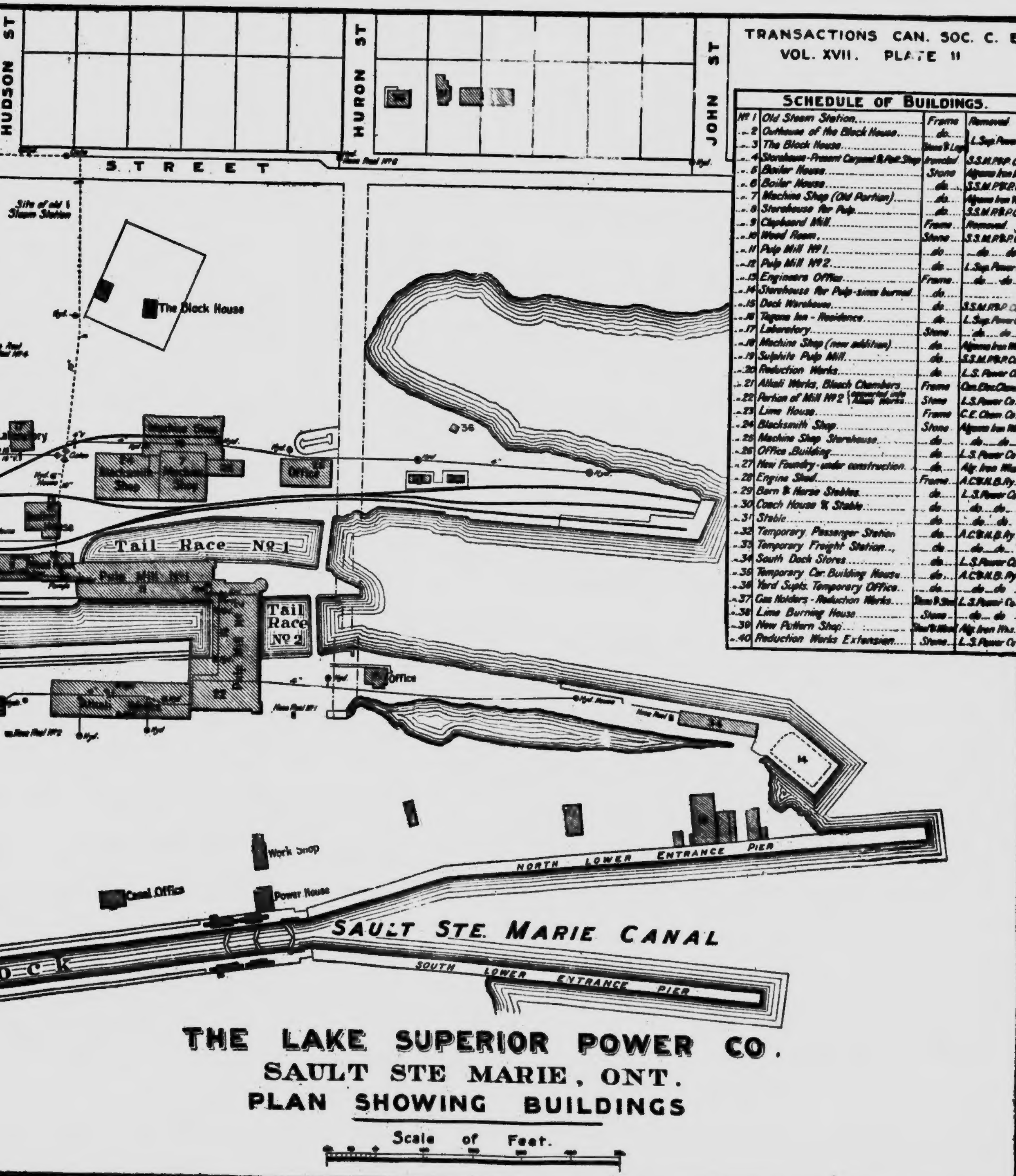
T.

TERS.



DIGESTER HOUSE.


JAMES ST
GEORGE ST
HUDSON ST
PORTAGE
Sault Ste Marie Bridge Co.
Right of Way
Foundry
Laboratory
Pulp Storehouse
Power Canal
Lime House
Lock
MOVEABLE DAM
Site of old Steam Station
37
28
42



SCHEDULE OF BUILDINGS.

No 1	Old Steam Station	Frame	Removed
2	Outhouse of the Block House	do.	L. Sup. Power Co.
3	The Block House	Stone & Logs	L. Sup. Power Co.
4	Storehouse - Present Carpent. & Patt. Shop	Ironclad	S.S.M.P.&P. Co.
5	Boiler House	Stone	Algoma Iron Wks.
6	Boiler House	do.	S.S.M.P.&P. Co.
7	Machine Shop (Old Portion)	do.	Algoma Iron Wks.
8	Storehouse for Pulp	do.	S.S.M.P.&P. Co.
9	Clapboard Mill	Frame	Removed
10	Wood Room	Stone	S.S.M.P.&P. Co.
11	Pulp Mill No 1	do.	do. do.
12	Pulp Mill No 2	do.	L. Sup. Power Co.
13	Engineers Office	Frame	do. do.
14	Storehouse for Pulp - since burned	do.	
15	Dock Warehouse	do.	S.S.M.P.&P. Co.
16	Tagona Inn - Residence	do.	L. Sup. Power Co.
17	Laboratory	Stone	do. do.
18	Machine Shop (new addition)	do.	Algoma Iron Wks.
19	Sulphite Pulp Mill	do.	S.S.M.P.&P. Co.
20	Reduction Works	do.	L.S. Power Co.
21	Alkali Works, Bleach Chambers	Frame	Can. Elec. Chem. Co.
22	Portion of Mill No 2 {converted into Alkali Works	Stone	L.S. Power Co.
23	Lime House	Frame	C.E. Chem. Co.
24	Blacksmith Shop	Stone	Algoma Iron Wks.
25	Machine Shop Storehouse	do.	do. do.
26	Office Building	do.	L.S. Power Co.
27	New Foundry - under construction	do.	Alg. Iron Wks.
28	Engine Shed	Frame	A.C.&H.B. Ry.
29	Barn & Horse Stables	do.	L.S. Power Co.
30	Coach House & Stable	do.	do. do.
31	Stable	do.	do. do.
32	Temporary Passenger Station	do.	A.C.&H.B. Ry.
33	Temporary Freight Station	do.	do. do.
34	South Dock Stores	do.	L.S. Power Co.
35	Temporary Car Building House	do.	A.C.&H.B. Ry.
36	Yard Supts. Temporary Office	do.	do. do.
37	Gas Holders - Reduction Works	Stone & Steel	L.S. Power Co.
38	Lime Burning House	Stone	do. do.
39	New Pattern Shop	Steel & Wood	Alg. Iron Wks.
40	Reduction Works Extension	Stone	L.S. Power Co.

THE LAKE SUPERIOR POWER CO.

SAULT STE MARIE, ONT.

PLAN SHOWING BUILDINGS